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RESIDENTIAL LOCATION WITH MULTIPLE WORKPLACES AND A HETEROGENEOUS HOUSING STOCK

by

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Ph.D. Dissertation
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Analytical models of the "economics" of the residential location behavior of urban households make several restrictive assumptions which may seriously affect their applicability. First, in these models all employment is assumed to be concentrated at a single geographical point, corresponding to the central business district (CBD) of the city. Secondly, as the models are formulated in terms of comparative statics under the assumption of long-run equilibrium in the housing market, the spatial characteristics of the existing stock of housing exert no influence upon the location choices of households (see bibliography items: 2,7,8,23,27).

Casual as well as scholarly appraisal of Americzn cities indicates that these assumptions are implausible and possibly misleading. In the first place, for most American cities, central business district employment (or employment at any other point) represents a small fraction of total employment; indeed for many metropolitan areas all central city employment represents somewhat

less than half of total employment. Moreover, the secular trend in the locations of employment reveals a persistent pattern of decentralization (6,18). In the second place, it is clear that the housing stock exhibits great spatial heterogeneity; at any distance from the CBD in virtually any city, a wide variety of housing alternatives is available. On the supply side of the market, many types of transformations of existing housing units are likely to be expensive, and in any year new construction represents only a small addition to the existing housing stock. On the demand side, it is clear that this heterogeneity matters to housing consumers (3,5,21,30,34,35,38).

The analysis presented in this thesis incorporates these basic characteristics of the housing stock--durability, fixity, heterogeneity and high transformation costs--and the polycentric nature of workplace locations into a model of residential choice by housing consumers. To achieve this realism in explaining the utility maximizing behavior of households in their residence choices, the long-run equilibrium character of the housing market (or the housing "sub markets") is ignored.

The alternative theoretical analysis makes several behavioral assumptions. First, we recognize that households usually have preferences for a number of housing attributes which can seldom be purchased separately. These attributes are typically available in more-or-less distinct combinations. We assume that these attributes are "packaged" so that there exist a finite number of housing types. Each housing type reflects specified levels of

each of the attributes of housing services, that is, each housing type represents a specific "bundle" of housing services (4,5).

Secondly, it is assumed that for each distinct housing type, the schedule of market prices at each location is known to the consumer. The schedule of prices for any housing type may reflect fully capitalized locational advantages and full adjustment to the equilibrium position of the market as a whole. Alternatively, the durability of the housing stock and the costs of converting units from one type to another may suggest that the price schedules reflect quasi-rents accruing to particular housing types in short supply at specific locations. The surface of housing prices confronting each household may thus be irregular and may even contain "holes" indicating the complete unavailability of particular types of housing at particular locations.

Thirdly, we assume that each household has a fixed workplace in the urban area. In contrast to the monocentric theories, we do not assume that all households are employed at the same point. We do, however, assume that the location of employment is determined for each household before it chooses its residential location. Since the choice of job and/or industry often depends upon particular training, investment, or aptitude which often preceed even household formation, it seems reasonable to make this assumption (37,38).

We thus assume that each household has an inelastic demand for work trips for a particular destination in the urban area, i.e., its workplace. We further assume that non-work trips (e.g.,

shopping, recreational, social trips) are made to ubiquitous and substitutable destinations.

Finally, we assume that households are capable of computing the monetary costs of their journeys to work. We make the behavioral assumption that households can, and do, value their travel time at some dollar amount. Ample theoretical justification for this assumption is available (9,17,25,26) and several empirical studies have attempted to infer households' monetary valuation of commuting time (10,13,22,39,41).

Under these assumptions, the household's decision (1) to choose a particular housing type and (2) to select a particular residential location can be separated analytically. For each housing submarket or housing type, the consumer can calculate the transport cost associated with location at each potential residence site. Since the schedule of prices at each residence site is known, the household can compute the total cost of consuming the given housing type at all residence sites. Since housing attributes are homogeneous for each housing type, the choice of the optimal location for consuming every housing type can be calculated as that residence site where the total cost of housing consumption is a minimum. Utility maximization implies that each consumer will determine the optimal location and the implied dollar expenditure for each housing type.

The consumer's ultimate choice of housing type and geographical location is a straightforward generalization of this analysis. For each housing type, the household calculates the gross

prices of housing and determines the optimal (least cost) location together with its associated dollar price. Consumers' choices among housing types result from utility maximizing behavior dependent upon income, preferences for housing types and other goods, the gross prices of each housing type at its optimal location, and the prices of other goods.

The crucial point that this alternative analysis illustrates is that the possibilities of substituting commute costs for housing prices in the search for an optimal residential location can be expected to vary for different types of housing and for different workplaces in any urban area. Because the location of the stock is essentially given in any market run and because the spatial distribution of housing types may vary markedly, the transport costs associated with consuming any housing type at its minimum priced location may vary substantially. Hence, the relative prices of housing types when viewed from different workplaces may vary substantially.

The model suggests at least two hypotheses which may be verified empirically. First, for a chosen type of residential housing, its location should be determined by a simple cost minimization calculus. For a sample of households making residential location decisions, each should choose that geographical location which minimizes the "gross price" of the chosen housing type. Since the "gross price" of housing is simply the sum of market prices and commuter expenses, the optimal residential location for any individual household varies systematically with the chosen type of housing, the location of the workplace, the

characteristics of the transport network, and household income (if the value of travel time depends upon income).

Secondly, the choice among housing types for any household is an explicit function of its set of minimum-gross-prices. The set of minimum gross prices will vary for households with different workplaces and different incomes. The empirical portion of this thesis attempts to test both of these hypotheses using a large sample of households and dwelling units from a single metropolitan area.

For a household with known income and workplace, if travel time expended by private auto and public transit is equally valuable, it follows from the model that the gross price (P^*_{hijk}) of housing type h at residential location i for workers employed at j of income class k will be equal to:

$$P^*_{hijk} = P_{hi} + N \min_{i'} (F_{i'j} + T^t_{ij} W_k V_k), \left(\frac{C_j}{2} + T^a_{i'j} E + T^a_{i'j} W_k V_k\right)$$

where:

P_{hi} = the monthly rent of housing type h at residential location i

N = number of work trips per month

$F_{i'j}$ = transit fare per trip from residential location i' to workplace j

$T^t_{i'j}$ = public transit trip time (in hours) between i' and j

W_k = hourly wage for income class k

V_k = value of travel time as a proportion of the wage rate for income class k

C_j = average cost of all day parking at workplace j

$T^a_{i'j}$ = private auto trip time between i' and j

E = out-of-pocket auto expenses per minute of driving time

The empirical analysis is based upon a sample of 24,626 households and dwelling units from the Pittsburgh region. (40). Housing types were defined using proxies for quality (age of unit), residential density (structure type) and interior size (number of bedrooms) (4,20,21); the surface of contract prices was defined as the average price of each (of h = 1, 2,...,30) housing types at each of 50 locations (i.e., i = 1, 2,...,50 zones). The location of the stock was described at each of 130 locations (i.e, l' - 1, 2,...,130 zones) and workplaces were described by 333 locations (i.e, j = 1, 2,...,333).

Although it is difficult to specify an appropriate value of travel time a priori, empirical research generally indicates that households value their travel time at less than their wage rates (10,13,22,39,41). Accordingly the hypothesis of gross-price-minimization was tested separately for assumed values of travel time equal to (V_k=) 0,20,40,60,80 and 100 percent of the wage rate.

The test of the gross-price-minimization hypothesis was accomplished by using the above equation to estimate the gross price surface facing each consumer for his chosen housing type and by noting his choice within the ordered set of gross prices.

The 130 x 333 matrices of transit and private auto times and fares were supplied for the Pittsburgh region; marginal auto expenses were estimated from Survey Research Center data (22). The analysis was performed for each of six income classes (i.e, k = 1, 2,...,6).

For a given value of travel time, the ordered set of gross prices facing a subsample of recent movers (3056 renter households and 4687 owners) was computed; these distributions vary by workplace, income class and chosen housing type.

The hypothesis was evaluated by noting the percentage of households choosing locations in the nth percentile of the ordered gross price distribution facing them. If households had perfect information and if all variables were measured properly, the hypothesis implies that each household would choose locations in the 0-1 percentile of its gross price distribution. The results indicate that at any value of travel time greater than 20% of the wage rate, consumer behavior conforms well to the hypothesis. For example, at a value of travel time equal to the wage rate, 52 percent of the renter households chose locations for consuming their preferred type of housing which were within the 10 percent of the housing stock with the cheapest gross prices when viewed from their workplaces and income classes. The gross-price-minimization hypothesis conformed better to consumer behavior for higher assumed values of travel time and for lower-middle income households (those earning between $3000 and $7000 per year in 1967 dollars).

The rationale for consumer behavior implied by this model is compared with that implied by several other trip distribution algorithms (11,14,15,16,29,31,32,33) and the same results are derived by generalizing the "intervening opportunities" model (31).

The second hypothesis is tested empirically by summarizing the gross price distribution facing each consumer for each type of residential housing and by estimating demand equations for the several attributes of housing. Each demand equation is estimated using the minimum-gross-prices of alternative housing types as an explanatory variable.

The results strongly indicate that consumers' choices among housing types are systematically related to the spatial variation in the gross prices they face. This spatial variation arises by recognizing the importance of multiple workplaces and spatially fixed housing stocks in a model of consumer choice.

The cost of consuming identical housing bundles varies substantially by workplace and this results in (1) systematic substitution in households' consumption of heterogeneous housing attributes, and (2) systematic substitutions of location for consuming these attributes. Neither of these issues is addressed satisfactorally by the existing monocentric equilibrium models of residential location.

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